

It was found on examining earlier plates that it could be traced back to January 27; before that date it was too far from the centre of the plate to be recorded. It was for some time doubtful whether it was a satellite or a minor planet that made a near approach to Jupiter; before the end of the apparition it was rendered tolerably certain that it was a very distant satellite with retrograde motion, and this has now been confirmed by the re-observation of the satellite in January 1909.

The coordinates given in *M.N.*, lxviii. 8, p. 581, are equivalent to the osculating ellipse given below.

Another ellipse was computed by Messrs. Crawford and Meyer, which is given for comparison:—

Epoch of Osculation. Perijove Passage.	<i>M.N.</i> , lxviii. 8, p. 581 1908 March 16 1908 Sept. 29.5	Crawford and Meyer 1908 March 8 ^d 20 ^h 1908 Aug. 25.72
ω	105°22	96°00
Ω	277°46	275°18
i	148°86	152°03
e	0.333	0.4395
period	830 days	931 days
a	0.1702	0.1837

The satellite was re-observed at Greenwich 1909 January 16; and as the place agreed more closely with that deduced from the first elements, these are probably nearer the truth than the others. In any case, there is now no doubt that the object is a retrograde satellite, with a highly eccentric orbit.

Bulletin Astronomique for October 1908 has an article by M. Gustaf Kobb on the stability of the orbits of the outer satellites of Jupiter. Satellites VI, VII are stable, but the earlier circular orbit for VIII given in *M.N.*, lxviii. 6, in which $a=0.213$, is shown not to satisfy the test that he uses. He has not yet applied his formulæ to the more accurate elliptical orbits given above, but it is evident that the satellite approaches somewhat nearly to the zone where the ordinary test of stability ceases to apply, which will add interest to the investigation of its motion.

Many observations of satellites VI and VII and of Phœbe have been made; the American Ephemeris now contains ephemerides of VI and Phœbe, and we understand that a second edition will contain one of VII.

A. C. D. C.

The Comets of 1908.

The observations of several comets discovered in 1907 have been continued into the year, but the number of fresh discoveries is unusually small.

Comet α 1908, the object photographed by Professor Max Wolf on December 25, 1907, and mentioned in the last Annual Report as an observation of Encke's Comet, has probably no connection

with that body. The January observations displayed such deviations from the computed path, and such discrepancies among themselves, that Professor Backlund doubted the identity of the two objects, but thought it desirable to re-compute the perturbations during the last period, though, from the fact that the process pursued in the calculations had been precisely the same as on former occasions, it was not likely that any accidental error would be detected. Moreover, the perturbations had been checked by two independent methods. The commensurability of the mean motions of Jupiter and the comet ensures that the perturbations will be approximately repeated after intervals of about fifty-nine years. Consequently the perturbations of the 1845-8 period is an efficient check on the accuracy of the work. In seventy-six years, the configurations of the Earth and comet also return with such exactness that Encke's ephemeris of 1832 provides a very complete control over that of 1908. The only result of the examination was to confirm the substantial accuracy of the ephemeris, to which greater precision was given by introducing terms of the second order depending upon the action of Jupiter. No computational explanation being forthcoming, Dr. Backlund suggested that while the object observed at Heidelberg could not be regarded as Encke's Comet, it was not impossible but that the comet had divided, and that, by the process of division, one of the parts had been turned into an orbit sensibly different from the original. Meanwhile, Dr. Ebell had computed a parabola direct from Dr. Wolf's measures, employing those made on January 2, 13, and 19. He found an orbit which represented the middle place with great accuracy, but had no similarity with that of Encke. The distinguishing feature of this orbit was the great perihelion distance, viz. 3.8 R. Dr. Weiss pointed out that the observed deviations from the path of Encke could not be explained by the motion of a single object, and suggested that the observations of December 25 and January 2 belonged to one object and the remainder to another, though it was not impossible that both might have originally formed parts of Encke's Comet. He selected the dates January 13, 15, and 19 as suitable to furnish a parabolic orbit, but in this instance the determination of (M) the ratio of the curtate distances at the first and third observations proved insecure, a very small variation in this quantity giving rise to very different orbits. It was possible to represent the measures in a satisfactory manner with elements in which the time of perihelion passage differed many months, and the values of perihelion distance ranged from unity to four times that amount. A value of (M) derived from the ephemeris of Encke's Comet was not more satisfactory, and an ellipse with a semi-axis major assumed at 2.216 led to no more conclusive result. The important fact that followed this investigation was the decision that Professor Wolf's object would not pass into the southern hemisphere as Encke's Comet did, and that it would be possible to observe the same object in May in the northern hemisphere, since the brilliancy would not greatly diminish, and the various orbits agreed in indicating the

position within tolerably close limits. So far as is known, however, the object or objects have not been again seen; and the curious fact remains, that after accurate observation for more than three weeks we are unable to determine the approximate path in which the object was moving. In some respects the history of this object recalls that of the famous Comet of D'Angos, each presenting a difficulty that has never been solved.

Comet *b* 1908 is the real Comet Encke, which was found at the Cape of Good Hope by Mr. Woodgate on May 27. Observation showed that the error of the ephemeris was + 5 m. 22 sec. in R.A. and - 33' in declination, deviations from the computed path as large as in the case of Professor Wolf's object, but at the end of May the comet was much closer to the Earth than in January. The comet was followed by means of photographs till the 5th. of June, but remained a very faint object.

Comet *c* 1908 was discovered by Mr. Morehouse of the Yerkes Observatory on September 1, and reported at the time as a conspicuous object with a long tail. This description seemed to indicate the approach of a brilliant comet, but for some time the increase in lustre was very slow. Subsequent observations revealed very great changes in the structure of the tail about the dates September 16, October 1 and 15, so that it is not impossible that at the time of its discovery the comet was undergoing one of those periodic fluctuations which temporarily increased the brilliancy. Though the comet became visible to the naked eye, its general appearance was disappointing; but, owing to the nature of the variations, its history is one of the most interesting in modern times. These changes have been unusually rapid, and even in its quieter moments photographs at very frequent intervals have been necessary to explain the changes in structure. At all the principal observatories a series of photographs has been obtained, and these have been amply supplemented by much admirable amateur work, to which it is impossible in this place to do adequate justice. The wealth of material collected has been so great that it has not yet been fully discussed. The one fact that stands out clearly established is, that the process of formation of the tail is intermittent rather than continuous. In no comet hitherto observed has this feature been so distinctly marked, or the motion of the matter forming the tail so clearly traced. The behaviour of the nucleus, the sequence of changes through which the comet passes as parabolic envelopes appear on the side towards the Sun, the sweeping round to produce a tail, fan-shaped and streaming, subsequently breaking up into flocculent masses, have never been demonstrated before with the same clearness, and the actual measurement of the motion of the material forming the tail has been possible under more favourable conditions than ever before. As a result, it has been recognised, both at Greenwich and Heidelberg, that the velocity of motion increases the further the matter is away from the nucleus. Professor Barnard calls attention to the sudden brightening up of parts of the tail where apparently no material

previously existed, and where there was no visible supply reaching it from the comet. This phenomenon is compared with what is frequently seen in auroral streamers. Others have questioned how far the motion is real or apparent. Some of Professor Max Wolf's photographs suggest that the presence of knots or condensations of material in the tail is due to the superposition of detached bands or rays crossing one another, giving rise to regions of increased brilliancy at the point of intersection, and shifting as these rays alter their relative positions.

The spectrum, which has been observed at many observatories, presents some unusual features. The continuous spectrum usually seen in bright comets has been exceedingly faint, and some observers report it absent. Some of the ordinary hydrocarbon bands have been seen by Frost and Parkhurst, whilst Deslandres and Bernard find no trace of them. The bands of cyanogen are incomplete, the second being wanting. At the Lick Observatory certain lines have been observed of which the origin is doubtful. They have not been identified with the lines of any element or compound hitherto examined in the laboratory. The presence of these unexpected lines in the blue and violet, and the faintness of the continuous spectrum, suggest an explanation of the great chemical activity and feeble visual intensity which have been marked features in this comet.

Comet *d* 1908 is a return of the Comet Tempel₃-Swift, which has not been seen since 1891. This faint comet was found at Nice by M. Javelle on September 29, employing an ephemeris furnished by M. E. Maubant. The observations show the necessity of an alteration in the computed time of perihelion passage of 3.646 days, or a diminution of the mean motion by 0".38. M. Maubant recalls the fact that M. Bossert, who computed the perturbations, small in amount, between 1880 and 1891, also found it necessary to reduce the motion by the same quantity in the same direction, and he suggests the possibility of the existence of a negative acceleration, of which some evidences have been detected in the motion of the periodical Comets of Tempel and of Brorsen.

The orbits of the following comets have been definitely determined during the year:—

Comet.	Character of Orbit.	Calculator.	Place of Reference.
1813 I.	Parabolic	H. A. Peck	<i>Ast. Journal</i> , No. 601
1826 V.	„	Hnatek	<i>Ast. Nach.</i> No. 4269 <i>Ast. Nach.</i> No. 4264
1886 V.	Ellipse	Bucht	<i>Schwed. Akad. der W.</i> <i>Stockholm.</i>

The past history of Halley's Comet, to which reference was made in the last Annual Report, has been further investigated by Messrs. Cowell and Crommelin, who may be heartily congratulated upon the success of their results. The path has been satisfactorily traced back to the beginning of the Christian era, and with great proba-

bility to some earlier returns. With regard to the coming apparition, Professor Holetschek, Dr. Smart, and others have published ephemerides to facilitate its recovery. The magnitudes assigned by the first-named astronomer show that, notwithstanding improved modes of search, there has hitherto been little chance of success.

Solar Activity in 1908.

Sun-spots.—Although several very fine spots have been seen on the Sun's surface during the year, especially two at the end of August and the middle of September, yet the general character, size, and positions of the spots denoted a decline in the solar activity. The first quarter of the year was marked by a quiet period, succeeding the great outbursts witnessed in November and December 1907. The groups observed were of no great area, and bright faculæ were relatively scarce, and mostly seen on the E. limb. The spot groups, too, were generally of the character denoted by Types I. and IV. which mark the quiet and dying phases of spot activity, with a very noticeable dearth of spots represented by the active Types II. and III. And in general this was the character of the spot groups observed during the year, with the exception of some outbursts to be noted directly. The long processions of groups prevalent in the years 1906, 1907 were replaced by a series of many round regular quiet spots, several of them affording excellent material for testing the Wilsonian hypothesis of sun-spot level.

The first active period of the year set in with the beginning of April, announced, as is so often the case, by the appearance of a bright compact patch of faculæ on the E. limb, and lasted until the middle of the month, with somewhat of a revival when the groups returned again at the end of the month. Even so, the general type of the spots noted above was preserved. But the faculæ were brighter and more abundant. A quiet May was followed by a revival of activity at the beginning of June, which was of no long duration, the quiet spell that succeeded lasting until the end of July. But now began the most active period of the year, covering the months of August and September, four of the groups observed being visible to the naked eye. The middle of August was marked by four fine groups, and an exceedingly fine group appeared towards its close. This, the biggest group of the year, was on the central meridian on August 31.2, and on August 30 covered a total area of about 1500 millionths of the visible disc. The next in size was group 6522 of the Greenwich series, which was on the central meridian on September 10.3 and was accompanied in its passage by a very violent magnetic storm, the greatest of the year. The region in which it appeared had been the seat of the great sun-spot group of November 1907 which had itself synchronised in its first passage across the disc with two days of great magnetic storm. However, after the fourth appearance of this same group, central on February 4.9, 1908, the region had